High bitrate Free-Space Optical communication at 9 µm wavelength using Unipolar Devices operating at room-temperature

H. Dely[1], T. Bonazzi[1], O. Spitz[2], E. Rodriguez[1], K. Pantzas[3], G. Beaudoin[3], I. Sagnes[3], L. Li[4], A. Giles Davies[4], E. H. Linfield[4], F. Grillot[2], A. Vasanelli[1] and C. Sirtori[1]

[1]*Laboratoire de Physique de l'ENS, Ecole Normale Supérieure - PSL, F-75231 Paris Cedex 05, France*

[2]*Télécom Paris, Institut Polytechnique de Paris, F-91120 Palaiseau, France*

[3]*Centre de Nanosciences et Nanotechnologies, Université Paris-Saclay, F-91120 Palaiseau, France*

[4]*School of Electronic and Electrical Engineering, University of Leeds, Leeds, LS2 9JT, UK*

Corresponding author: hamza.dely@ens.fr

Unipolar quantum optoelectronic devices rely only on transitions between electronic states in the conduction band. These devices are promising for high-frequency operation in the mid-infrared due to very fast relaxation times of electrons in the excited states, in the order of few picoseconds [1]. As their operation wavelengths are in the atmospheric transparency windows ($\lambda \sim 4$ –5 µm; $\lambda \sim 8$ –14 µm), they are suited for long range free-space optical communication at very high-bitrates [2]. Several options are available including direct or external modulation of phase and/or intensity.

In this work we present data transmission results obtained using a setup based on $\lambda = 9$ µm unipolar devices operating at room-temperature: a continuous wave (CW) quantum cascade laser (QCL), a quantum cascade detector (QCD) [3] with an external intensity modulator based on the quantum-confined Stark effect in between. This modulator is designed to avoid charge displacements in the quantum structure and allows bandwidths up to few tens of GHz. We achieved 8 Gbit.s^{-1} bitrate with a bit error rate (BER) of 10^{-3} which can be corrected with negligible overhead using error correction code (ECC) [4]. To the best of our knowledge, this is an improvement of two orders of magnitude with respect to the state-of-the-art [5].

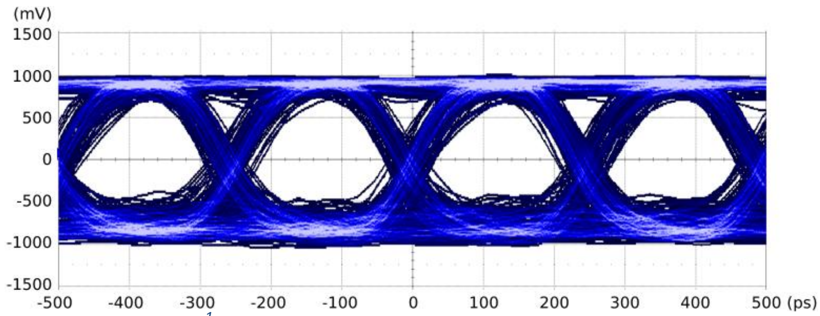

Figure 1: Eye diagram measured at 4 Gbit.s^{-1} with a high-speed oscilloscope used to evaluate the quality of a data transmission. An opened eye showing well-resolved high and low states (ones and zeros) indicates a good transmission quality with a low BER. Here, the BER extracted using the data analysis software of the oscilloscope is lower than 10^{-21}.

References:

[1] R. Paiella et *al*. Appl. Phys. Lett. 79, 2526 (2001)

[2] A. Delga and L. Leviandier, Proc. SPIE 10926, 1092617 (2019);

[3] A. Bigioli *et al.*, Appl. Phys. Lett. 116, 161101 (2020)

[4] O. Ozolins et *al*. 45th Eur. Conf. on Opt. Comm. (ECOC 2019), pp. 1-4

[5] T. Li et *al*. Photon. Res. 7, 828-836 (2019)